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EXPOSED TO RELATIVE ISOLATION

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STUDY OF THE WORK AND REST CYCLES OF TEST SUBJECTS
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ABSTRACT. Results of two 15-day experiments on three test subjects in a sealed chamber, with 24- and 18-hour rest and work cycles, are given. The 18-hour cycle had a greater effect on psychic functions, cardiovascular system, nervous and muscular activity, and caused more pronounced biochemical changes, indicating the development of nervous and emotional stress. Objective and subjective observations on reaction of the organism to the two cycles are tabulated and plotted.

In connection with the prospect of prolonged space flights, the development of optimum conditions of life for subjects who stayed for protracted periods of time in enclosed spaces of small volume becomes of particular interest.

The literature data indicate that the experiments in this field as a rule concern studies of the life cycles either of a single subject or of a group of subjects with a common sequence of work and rest (F.D.Gorbov et al. ; O.N.Kuznetsov et al.; Hauty; Weybrew).

In two 15-day experiments on three test subjects, we studied the behavior and activity of a group of persons exposed to the same hygienic conditions in a sealed chamber, but with different circadian rhythm of work and rest.

The studies were made in a sealed chamber of 23 m³ volume (with volume of the atmosphere being 15 m³) consisting of a welded metal structure. The noise level in the chamber did not exceed 50 - 60 db; the illumination in the chamber was constant while that of the work places was 100 lux.

The temperature of the air throughout the experiment did not exceed 25°C, /55 the relative humidity was 60%, the oxygen content about 25%, and the carbon dioxide ranged from 0.55 to 0.8%. Systematic analyses of the air for harmful impurities showed that, in its chemical composition, it met hygienic standards (these studies were made by V.V.Zhuravlev and V.P.Savina).

The test subjects were I. who was a 30-year old physician; M. a 27-year old physician; and S. a 25-year old mechanic.

In the first experiment, we studied the effect of a 24-hour cycle, with the day divided into 8-hour periods of sleep and alternating 4-hour periods of work ("watches") and rest. At each given instant, the subjects were in different states (one of them slept, another was on watch, the third rested, read, took

* Numbers in the margin indicate pagination in the foreign text.

care of personal hygiene, etc.).

In the second experiment we tested the 18-hour cycle, divided into 6-hour periods of sleep and alternating 3-hour periods of "watch" and rest (Tables 1 and 2).

TABLE 1

ALTERNATION OF PERIODS OF WORK AND REST IN THE FIRST
EXPERIMENT (24-HOUR DAYS)

Subject	Hours					
	12-16	16-20	20-24	24-4	4-8	8-12
I.	Watch	Watch	Self-care	Sleep	Sleep	Self-care
M.	Sleep	Self-care	Watch	Self-care	Watch	Sleep
S.	Self-care	Sleep	Sleep	Watch	Self-care	Watch

TABLE 2

ALTERNATION OF PERIODS OF WORK AND REST IN THE SECOND
EXPERIMENT (18-HOUR "DAYS")

Subject	Hours					
	12-15	15-18	18-21	21-24	24-3	3-6
I.	Sleep	Sleep	Self-care	Watch	Watch	Self-care
M.	Watch	Self-care	Watch	Self-care	Sleep	Sleep
S.	Self-care	Watch	Sleep	Sleep	Self-care	Watch

The physical condition of the subjects was evaluated by a group of physiological, psychological, and biochemical examination methods and also on the basis of general objective observation of the subjects, time study of their activity, and subjective or self-observation.

The distribution of the time periods and their duration differed in the first and second experiments. Of course, in the second experiment with the 18-hour daily cycle, the share of periods of work and rest of the subjects was

increased, i.e., the number of these periods was increased while their duration was reduced. /56

This had a substantial effect on the behavior of the subjects: In the second experiment, the time required for a number of operations (eating, research work, physical exercise, etc.) was appreciably shortened. While the meals (breakfast, lunch, dinner) in the first experiment took the subjects 20 - 25 min, they took no more than 10 - 15 min in the second experiment. The time required for performing a given group of physical exercises increased, which was particularly evident on the motion-picture frames. In the first experiment, the physical exercises were performed for the most part at a slow and moderate rate whereas, in the second experiment, the rate most often was moderate to fast, which shortened the total time required for the group of physical exercises (while maintaining the necessary level of energy expenditure). In the second experiment, the subjects showed a peculiar "restlessness", which evidently was a proof for the greater difficulty in adapting to this peculiar cycle. The subjects frequently changed position and were unable to stick for long to the same occupation, such as reading a book. The accelerated rate of alternation of sleep and waking confused their concept of distribution and passage of time (B.A.Dushkov and F.P.Kosmolinskiy).

During the first days of their stay in the sealed chamber in the first experiment, the subjects seated in a chair during the watch frequently dozed off. Subjects M. and S., whose diurnal cycle differed from the customary, woke up more slowly and fell asleep earlier than called for by their schedule. This was less pronounced in the subject I., since his sleeping time fell into the customary night hours. After 6 - 8 days in the sealed chamber, both self-consciousness and mood of the subjects improved somewhat, which indicated a certain adaptation of the body to the new diurnal rhythm.

During the first days of the second experiment all the subjects were in a semisomnolent state for a considerable part of the day, especially on watch, and were struggling with drowsiness. They noted that during the scheduled sleeping time they slept poorly, while in the periods of work and active rest they constantly felt the desire to sleep, that the second regime on the whole was more difficult to support than the first, and that it was harder to become accustomed to the change.

It was found that during the experiment the need for motion increased and that also the number of movements of hands, feet, body, and head when sitting in the chair increased here. In addition, the desire to communicate with one another and with the experimenters (by radiotelephone) also became greater. Toward the end of the experiment (after 13 - 15 days), especially in the second experiment, the subjects became more irritable and showed signs of fatigue; a certain impairment of motor coordination in performing the physical exercises was noted.

The data of these observations are in agreement with the results of the psychological, electrophysiological, and biochemical examinations.

The disturbance of the familiar vital cycle also modified the functional state of a number of systems of the body. Thus, in the first experiment, the changes in the maximum and minimum arterial pressure of the subjects M. and S.

whose sleep period fell into the daylight hours, were more extensive than in the subject I. who was under the customary work and rest cycle (sleep at night). The shifts in the blood pressure indices were more distinct in the experiment with the 18-hour "diurnal" cycle.

The mental processes during the stay of the subjects in the sealed chamber likewise showed certain changes; the number of inaccurate answers increased /57 and the time taken for performing attention tests also increased, the accuracy of reproduction declined, and the volume of remembered material decreased. All these indices changed more substantially in the second experiment than in the first.

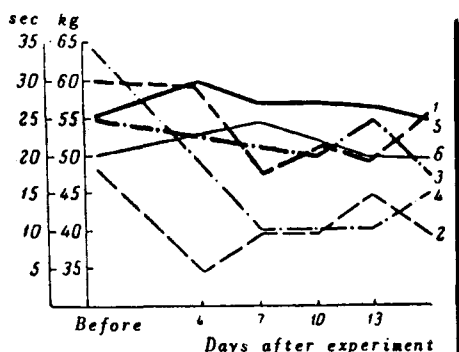


Fig.1 Changes in Muscle Force and Strength.

1 - Force in S.; 2 - Tolerance in M.;
3 - Force in M.; 4 - Tolerance in S.;
5 - Force in I.; 6 - Tolerance in I.

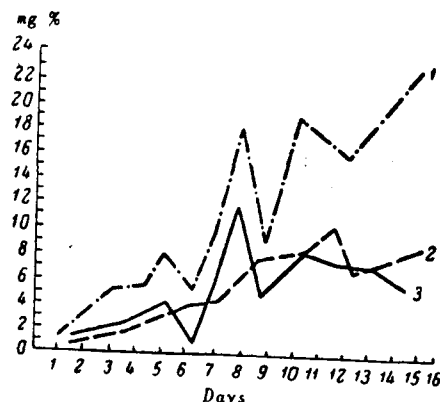


Fig.2 Variation of Ascorbic Acid in the Urine of the Subjects in the First Experiment.

1 - In I.; 2 - In M.; 3 - In S.

In the second experiment, pronounced shifts were observed also in the neuromuscular activity which, in all probability, were connected with the functional changes not only of the respiratory center of the cerebral cortex but also of the peripheral connection of the neuromuscular apparatus.

Also of significance are our data from a study of muscle force and muscular strength of the wrist, musculo-articular sensitivity, time sense for slight and great measured effort. The most pronounced changes in these indices were noted in the subject M. By the end of the second experiment, his muscle power had decreased by 7 kg. The muscular strength of the subject S. was considerably lowered; after the second experiment it decreased for the right hand from 35 to 17 sec, and for the left hand from 42 to 12 sec. The muscular strength measured before the first watch (i.e., immediately after sleep) over the course of the entire experiment (4, 7, 10, and 13 days) was higher than after the watch. Somewhat lesser changes were noted in subject I. (Fig.1).

Several biochemical studies to determine the level of the nervous and emotional (stress) state of the subjects are of interest. One of the indices of stress reactions, in particular, may be the intensified excretion of ascorbic

acid (as an adrenal reaction) which has been shown by us earlier (F.P.Kosmolinski et al.).

Before the first experiment, the ascorbic acid level in the urine of the subjects I., S., and M. was rather low (0.36, 0.38, and 0.4 mg%, respectively). In the following days, this level rose gradually (Fig.2).

The ascorbic acid excretion in the urine of all subjects before the second experiment was 2 - 3.2 mg/day. During the second experiment it gradually increased: on the 5th day it was 13.6 mg/day for M., 12 mg/day for S., and 6 mg/day for I. It then declined somewhat and again rose toward the end of the experiment. By the end of the experiment it had risen to 15 mg/day in M., to 58 13.9 mg/day for S. and to 20.2 mg/day for I. (Fig.3).

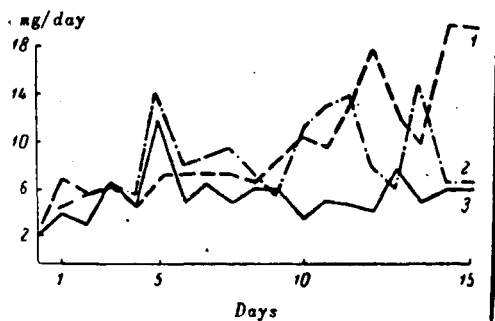


Fig.3 Variation of Ascorbic Acid Excreted in Urine of Subjects during Second Experiment.
1 - I.; 2 - M.; 3 - S.

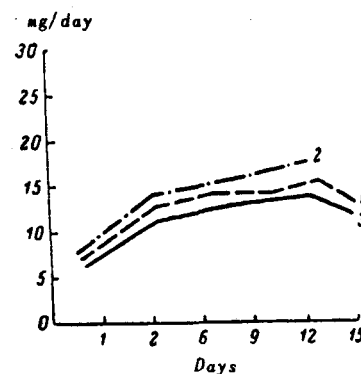


Fig.4 Variation of 17-Ketosteroids Excreted in Urine of Subjects during Second Experiment.
1 - M.; 2 - I.; 3 - S.

In the second experiment, we also determined the urinary excretion of 17-oxycorticosteroids and 17-ketosteroids (according to Reydi). The 17-oxycorticosteroid excretion rose gradually in all subjects. Thus, during the first day of the experiment, it was 9.6 mg/day for M., 9 mg/day for S., and 10 mg/day for I. whereas toward the end of the experiment it had increased to 14, 13.7, and 18 mg/day, respectively (Fig.4). The 17-ketosteroid excretion was increased parallel to that of the 17-oxycorticosteroids (these studies were performed by N.I.Andrzheyuk).

Thus, the results of our study of the life cycles of a group of subjects under conditions of relative isolation show that variations in the distribution and duration of the time periods affect the regular biological cycles and functional state of various systems of the organism.

We noted physiological and biochemical processes of adaptation to changes in the daily routine, which were more pronounced in the first experiment. Shortening of the period of work and rest and the resultant increase in the rate of activity in the second experiment induced a more significant physiological stress.

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